Knowledge Systems for Coalition Operations

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Coalition operations have emerged as a key feature of military and humanitarian interventions over the past two decades. In a coalition operation, two or more nations or agencies act together to accomplish anything from a major combat operation to a peacetime humanitarian mission.[1] Coalitions typically consist of a collection of multinational military forces—often working alongside nonmilitary organizations such as the UN and nongovernmental organizations (NGOs)—to support missions with objectives set by consensus in the international community (for example, through the UN). These missions require agility and effective use of limited resources to achieve complex and multiple objectives. Participants must assemble and maintain a "virtual organization" reflecting the interests of participating countries, NGOs, and agents from the host nation.[2]

The situation in these missions is typically fluid, resulting in frequent changes in strategies and objectives. Commanders must be able to clearly define and relay the mission objectives to planning and logistics staff, and from there to coalition partners and field personnel. They also need means for sharing information between the coalition partners

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and informing the public and media to counter misinformation.

KSCO Research

The Knowledge Systems for Coalition Operations (KSCO) community is an international organization exploring research in using knowledge-intensive systems to support both military and civilian coalition operations. At KSCO's frequent technical conferences, practitioners and key decision makers in coalition operations meet with researchers in knowledge-based systems, information management, planning, and multiagent systems to exchange experience and ideas, share inspiration, and suggest novel concepts. Over the past 15 years, the community has come together seven times in locations such as Edinburgh, Vancouver, and, most recently, Pensacola, Florida. Papers and presentations from all these events are available via the KSCO community website at http://ksco.info/.

In 2002, *IEEE Intelligent Systems* published a special issue on KSCO topics that included key papers from the 2nd KSCO conference held in Toulouse, France. The current special issue celebrates a further decade of KSCO activities covering a broad range of coalition-inspired research and application areas. In all this work, several topics frequently occur.

Frameworks and Infrastructure

Papers on this topic describe general-use models and systems that enable a broad use of information technology in coalition situations. Examples include a foundational effects-based method for framing information to enable better decision making, virtual environments for augmenting the coordination of distributed coalition partners, and a model for characterizing information management in a coalition "infosphere."

Planning and Execution

Plans and planning are integral to any effective coalition, be it military or civilian. Such papers focus on computational methodologies and mechanisms to enable efficient coalition planning. Examples include a formal language to describe plans shared among coalition partners that supports mixed-initiative planning, a case study of how the organizers of a recent Olympic Games planned for cybersecurity, and the use of multiagent systems to carry out and monitor planning in highly dynamic environments.

Coordination and Collaboration

Once a coalition's activities are collectively planned, members must execute and monitor them in a coordinated fashion. This topic has centered on models and software systems that let small groups of coalition partners collaborate and coordinate joint activities in a tightly integrated manner. Examples include a constraint-satisfaction methodology to enable better team interaction, a resource management system that lets coalition partners better access items they might have access to from other members, virtual operations centers, and studies on how dynamically formed communication networks within a coalition impact distributed problem solving.

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Understanding and Trust

To maintain an effective coalition, members must be able to understand their partners' needs and capabilities, believe that those partners will carry out agreed-on tasks, and trust that they're providing accurate information. Papers in this topic area have discussed ways in which information technology could help ensure this understanding and trust among coalition partners. Examples include semantic technology that helps improve information exploitation within coalitions and an automated approach to evaluating the trustworthiness of information that coalition partners provide.

Information Sharing

Effective coalitions must share information about everything from shared goals and activities, situation awareness, available resources, member capabilities, and joint plans. Contributions in this area have presented foundational frameworks and mechanisms to enable efficient and effective information sharing in a way that all members can understand and use. Examples include using common ontologies within a coalition to minimize the ambiguity of shared information, using well-defined and agreed-on standards for information representation and communication, and employing formal methods to capture and disseminate command "intent" in a coalition environment.

Cultural Issues

Many coalitions involve multinational partners, each with its own unique cultural perspective on the joint operations in which the team is engaged. Research in this topic describes the critical need for cross-culture awareness and understanding in multinational coalitions. Examples include how different cultures

approach critical coalition processes such as planning and information sharing, and a model of how the neurodynamics of situational awareness influence, and are influenced by, cultural norms and perceptions.

Command Interfaces

Information systems for supporting coalition operations must be able to provide accurate and timely information to a variety of users. Ensuring that these systems present an interface that can be effectively used by people with different technological backgrounds, cultural experiences, and interest in detail is critical to making them useful. In this topic area, papers have presented models and methodologies to define command interfaces for coalition information systems. Examples include computer-assisted interaction with information systems through intelligent virtual assistants and a methodology for defining compact interfaces for smartphones.

Applications

Over the years, the KSCO conferences have attracted a variety of guest speakers and technology developers with real-world experience operating in past and ongoing coalitions. Many speakers and contributors have had first-hand experience with using information technology to enhance their coalitions' effectiveness. Topics areas range from medical applications used to support disaster relief efforts to data collection at Olympic events.

In This Issue

For this special issue of *IS*, we've selected articles that cover work by academic, government, and industry researchers worldwide who are working together to develop knowledge systems to support such coalition operations. For example, the International Technology Alliance (ITA) program (www.usukita.com), established in 2006, is a joint UK Ministry of Defence and US Army Research Laboratory funded research project in network and information sciences. The ITA community, consisting of 24 academic and industry partners, is just one example of a large body of people actively engaged in research to support coalition operations; several articles in this special issue report on this work's results.

The article on "Improving Coalition Planning by Making Plans Alive," by Jitu Patel, Michael C. Dorneich, David Mott, Ali Bahrami, and Cheryl Giammanco, covers work by the ITA and addresses an important aspect of plan sharing and communication in coalitions via plans. The authors have done extensive work in the intelligent systems field and with a broader community of those involved with plan sharing to produce "standard" ways of representing and communicating plans. This work has drawn on a wealth of background information and made a significant contribution with a *collaborative planning model* (CPM) in the context of plan sharing across tools from different countries and agencies. The authors' aim is to make plans come alive by ensuring that dynamic use and refinement are possible across the agencies involved in complex coalitions and other rapidly changing situations.

In "Knowledge Management for Coalition Information Sharing at the Network Edge," Cheryl Giammanco, Ray McGowan, Anne Kao, Dave Braines, Stephen R. Poteet, Tien Pham, and Ping Xue describe further work in the ITA. Their article focuses on the important and recurrent KSCO theme of information sharing. In particular, they address getting information to the "edge of the network"—that is, the individual operators in the field or the soldiers in a theatre of operations. The article describes a way to query and gather information from a range of sources and communicate it both to and from those involved via a form of Controlled English (CE). The authors illustrate their concepts via a coalition Afghanistan agribusiness development and provincial reconstruction effort.

Continuing with the information-sharing theme, "Knowledge-Based Approaches to Information Management in Coalition Environments," by Andrzej Uszok, Larry Bunch, Jeffrey M. Bradshaw, Thomas Reichherzer, James Hanna, and Albert Frantz, describes an approach based on natural language and case-based reasoning to assist in releasing critical information to coalition partners in a controlled and timely fashion. The authors have used their knowledge-based approach to extend the US Air Force Research Laboratory's Phoenix information management system to provide more efficient ways of subscribing to and querying for information from coalition partners. The system automatically checks whether the requested information can be released without violating policies and identifying other relevant information of interest to subscribers.

"Developing Multiagent Algorithms for Tactical Missions Using Simulation," by Antonín Komenda, Jiří Vokřínek, Michal Čáp, and Michal Pěchouček, focuses on coordination and collaboration. The authors present a methodology for validating and verifying algorithms for multirobotic teams providing support to coalition operations. Their approach is based on the simulation-aided design of multiagent systems (SADMAS) and

implemented in their Alite software toolkit for multiagent prototyping. The authors demonstrate their approach's practicality via a multiagent application that uses game-theoretic, plan repair, and multiagent coordination algorithms to control a simulated robotic team supporting simulated troops in an evacuation mission.

Uncertainty, often arising from a lack of situation awareness and common understanding, is a significant problem in military environments. It's exacerbated within coalition operations given the restrictions on information sharing and differences in trust, common ground, and cognitive bias. In "Collective Sensemaking and Military Coalitions," Paul R. Smart and Katia P. Sycara describe a computational model of collective sensemaking. They further analyze the effects of communications networks and various network topologies on coalitions' ability to achieve collective sensemaking.

"Agilely Assigning Sensing Assets to Mission Tasks in a Coalition Context," by Alun Preece, Tim Norman, Geeth de Mel, Diego Pizzocaro, Murat Sensoy, and Tien Pham, presents a knowledge-based approach for automatically selecting and suggesting available sensing assets for tasks in intelligence, surveillance, and reconnaissance coalition operations. This topic represents a good example of using state-of-the-art information technology to let coalition partners collaborate in their joint efforts through resource sharing. The approach uses a representation of domain concepts and their relations based on an ontology, along with a knowledge base to store facts and corresponding methods for matching tasks against resources. The article also presents prototype mobile applications that could provide a front end for interacting with Sensor Assignment to Missions (SAM) to obtain recommendations of suitable assets for task allocations.

Finally, in "Extending Net-Centricity to Coalition Operations," Niranjan Suri, Andrzej Uszok, Rita Lenzi, Maggie Breedy, Jeffrey M. Bradshaw, Yat Fu, James Hanna, Vaughn T. Combs, Asher Sinclair, and Robert Grant provide the perfect example of how an information management system based on a service-oriented architecture (SOA) can support more agile information sharing between coalition partners. The authors characterize the Phoenix system as being ready to provide the fundamental infrastructure for realizing David Alpert's vision of a network-centric approach to future military missions. Furthermore, they identify the issues involved in applying this model to coalition information sharing, proposing that a federated SOA environment with policy-based information-sharing controls could improve this situation.

We hope that this collection gives an insight into the many exciting and productive research and development areas in knowledge systems for coalition operations.

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